RTT TECHNOLOGY TOPIC
January 2023

5G and Space Radio Spectrum

Over the next eleven months (January to November 2023) we will be making our way through the eleven chapters of our new book, 5G and Satellite RF and Optical Integration, highlighting recent industry announcements that hopefully help to consolidate the underlying narrative of an emerging market for 5G services from space coupled to increasing use of optical free space technology for inter satellite, inter constellation and earth to space/ space to earth links.

As a reminder,
Chapter 1 covers 5G radio spectrum including RF C Band, RF link budgets and active and passive device efficiency.
Topics addressed in the rest of the book include
Chapter 2 Optical C Band link budgets and active and passive device efficiency
Chapter 3 RF over Fiber- link budgets and network architectures
Chapter 4 Space RF Link Budgets
Chapter 5 Optical Inter Satellite Links (OISL)
Chapter 6 Deep Space and Near Space technologies
Chapter 7 Ground Station and Earth Station Hardware and Software
Chapter 8 Low Altitude Platforms
Chapter 9 High Altitude Platforms
Chapter 10 RF and Optical Technology Enablers
Chapter 11 Technology Economics of RF and Fiber for terrestrial and space networks.

For more information and to order go to

https://uk.artechhouse.com/5G-and-Satellite-RF-and-Optical-Integration-P2194.aspx

Hard and soft copies of the two previous books in the Series can be ordered here
https://uk.artechhouse.com/5G-and-Satellite-Spectrum-Standards-and-Scale-P1935.aspx
https://uk.artechhouse.com/5G-Spectrum-and-Standards-P1805.aspx

If you are interested in writing a book for Artech House or have research work you would like included in future 5G and 6G satellite RF and optical titles then email geoff@rttonline.com who will put you in touch with the Artech commissioning team.

We are also running a workshop on LEO, MEO, GSO, LEO, 5G, RF and optical integration in Prague 8th to 12th May 2023.

More information here
www.cei.se/continuing-education-institute/satellite-communications.html

5G Radio and Space Radio Spectrum (Chapter 1)

This is the Seventh book written by RTT either with co-authors (the first four books) or on our own (the last three books). If you like collecting complete sets then it is possible to buy a copy of all seven books though the first three are mainly useful as a reminder of how things used to be.

The full list is here
www.rttonline.com/books.html

We think our most recent book is the best yet. It is certainly timely.

The announcement last September from Apple and Globalstar that the iPhone14 would support emergency distress messaging marks the first step towards a 5G network in space. Announcements from T-Mobile and Starlink and start-ups, Lynk and AST (with AT&T) similarly show that ubiquitous emergency service coverage for smart phones from space is close to becoming a practical reality.

Getting enough power and RF bandwidth into orbit to support a broader range of smart phone services is, however, a massive engineering undertaking with enormous financial risk. Extraordinary levels of innovation are needed not only in RF transport and smart antennas but in optical cross connect and optical ground station technology.

The space sector is already growing at unprecedented speed, turbo charged by military spending on RF and optical sub metre resolution imaging from LEO and near space and air space intelligence assets. In parallel, new generations of radio and optical space based telescope are providing us with spectacular insights into the origins of the Universe.

All of these domains are enabled by RF and optical devices that have to be capable of working in extra ordinary extra-terrestrial, near space and deep space operational environments. This means engineers need to know how to make RF and optical products and RF and optical systems work in space both separately and together. At system level, software engineers need to understand how to integrate terrestrial and space network topologies.

The emerging narrative of our last three books has been that the cost of connectivity from terrestrial networks is increasing over time. The cost of connectivity from space based networks is decreasing over time. The cost of connectivity over radio networks is increasing over time. The cost of connectivity over optical networks (fiber and free space) is decreasing over time.

There are multiple reasons for this shifting cost base and we are not going to list them all as we want and need you to spend some money with us but essentially a mix of technology, engineering, economic, financial and regulatory factors determine absolute and relative delivery cost.

Starting with the last factor first, the regulatory climate over the past thirty years has created an auction process that has resulted in terrestrial operators spending hundreds of billions of dollars on radio spectrum and the same amount again on infrastructure investment.

By comparison, satellite operators have generally been gifted radio spectrum and use or lose regulatory mandates have been lightly enforced. In the context of upwards of a trillion dollars of terrestrial network investment,10 billion dollars to deploy a global 5G high count LEO constellation looks like a bargain.

But in many ways this is only a small part of the RF cost equation. Each of the three ITU regions have distinct band plans so although your smart phone will work in every country it only does that by supporting multiple bands many of which never get used. Multiple band support also reduces the RF efficiency of the phone on the receive and transmit path (insertion loss and compromised power and noise matching).

By comparison satellite operators have generally used one radio band to deliver global coverage. Conveniently some of these are adjacent to 4G and 5G bands, the Globalstar S band allocation being an example.

In an ideal world, a common 5G band would be specified that would work across all terrestrial and space networks but this seems unlikely to happen but is a problem that needs to be solved in order to make 5G in space economically sustainable.

As a rough rule of thumb an additional RF link budget of around 30dB is needed to deliver 5G from near space orbits. AST achieve this by deploying a 64 square meter array which is a mechanical and electrical work of wonder but in common with smaller phase arrays these are relatively narrow band devices. Deploying multi band arrays in space capable of spanning sub 1 GHz, L Band, S Band, C Band and the K bands (FR2 in 3GPP speak) is dauntingly difficult. To put this in context, a multi band multi operator terrestrial cellular site will now typically be generating several kilowatts of RF power modulated on to multiple spectrally efficient but power inefficient radio carriers.

Putting that much power into space is expensive and that's before you factor in the cost of RF interference and protection ratios. The announcement by Starlink that their second generation satellites will be more than four times heavier than their existing satellites (1250kg rather than 259kg) provides an indication of the scale of the investment but also highlights the potential return.

The extra weight means that Starlink can put more transmit power and receiver gain into space which means that the size, cost and complexity of terrestrial user terminals reduces, taking the service offer closer to a broad band user experience in a more or less standard smart phone. Additional revenue streams from multiple defence and civilian payloads will help the economics of the service offer as will optical cross connect and optical uplinks and downlinks. The optical links also help resolve the interference and protection ratio problem.

All of which helps to introduce next month's Technology Topic in which we compare and contrast the delivery economics of RF C Band and Optical C band for space based 5G connectivity.

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About RTT Technology Topics

RTT Technology Topics reflect areas of research that we are presently working on. We aim to introduce new terminology and new ideas to help inform present and future technology, engineering, market and business decisions.

The first technology topic (on GPRS design) was produced in August 1998. 25 years on there are over 270 technology topics **archived on the RTT web site.**

Do pass these Technology Topics and related links on to your colleagues, encourage them to join our **Subscriber List** and respond with comments.

Contact RTT

RTT and **Niche Markets Asia** are presently working on research and forecasting projects in the mobile broadband, public safety radio, satellite and broadcasting industry and related copper, cable and fiber delivery options.

If you would like more information on this work then please contact **geoff@rttonline.com**
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